

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. <b>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</b>					
1. REPORT DATE (DD-MM-YYYY) Sep 2010		2. REPORT TYPE		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Military Communications and Networks (Communications et réseaux militaires)				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Research and Technology Organisation (NATO) BP 25, F-92201 Neuilly-sur-Seine Cedex, France				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) RTO-MP-IST-092	
12. DISTRIBUTION / AVAILABILITY STATEMENT  DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES Supporting documents are attached to the report as separate files (MS Word, MS PowerPoint, PDF, HTM, etc.).					
14. ABSTRACT The dynamic and critical nature of information flow in present and future military operations demands high capacity, reliability, and robustness in the information grid. Current and projected military communication infrastructures, especially at the lowest tactical levels, may not meet requirements due to highly dynamic missions and organizations; complex terrain and topology, high demand for complex services, interoperability, availability and quality. Typical tactical networks are characterized by low bandwidth, variable throughput, unreliable connectivity and energy constraints imposed by radio channels and mobile operations. Many research and standardization efforts have been undertaken in the commercial market aimed at delivering new capabilities to mobile users and improving performance of wireless communication networks. Direct implementation of these solutions in tactical environments is limited due to specific military requirements related to interoperability, accessibility, security, mobility, flexibility, and more. This situation calls for detailed examination of already existing and emerging technologies, ongoing research efforts, as well as development and documentation of effective tactics, techniques and procedures that fully support the deployment of tactical communication networks which operate in a fashion that enables Network Centric Operations.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
U	U	U	SAR	9	



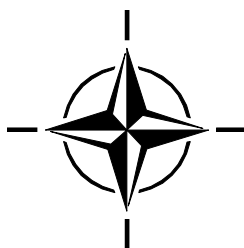
**RTO MEETING PROCEEDINGS**

**MP-IST-092**

# **Military Communications and Networks**

(Communications et réseaux militaires)

Papers presented at the Information Systems and Technology Panel (IST)  
Symposium held in Wroclaw, Poland from 28 to 29 September 2010.



Published September 2010

---



# The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT    Applied Vehicle Technology Panel
- HFM    Human Factors and Medicine Panel
- IST    Information Systems Technology Panel
- NMSG    NATO Modelling and Simulation Group
- SAS    System Analysis and Studies Panel
- SCI    Systems Concepts and Integration Panel
- SET    Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

The content of this publication has been reproduced  
directly from material supplied by RTO or the authors.

Published September 2010

Copyright © RTO/NATO 2010  
All Rights Reserved

ISBN 978-92-827-0126-2

Single copies of this publication or of a part of it may be made for individual use only. The approval of the RTA Information Management Systems Branch is required for more than one copy to be made or an extract included in another publication. Requests to do so should be sent to the address on the back cover.

---

# **Military Communications and Networks**

## **(RTO-MP-IST-092)**

### **Executive Summary**

The Symposium took place in conjunction with the Military Communication and Information Conference (MCC), which is a well established conference bringing mostly European experts in the military CIS domain together. There have been joint sessions between both events in overlapping areas.

The topic of the Symposium was on communication systems and wireless networks addressing recent developments in those areas.

The Symposium was organized in 3 joint and 5 Symposium only sessions. The joint IST/MCC plenary session presented an overview and two invited papers. The first one gave an insight into body centric communications, which may play a significant role for concepts for wireless networking in future soldier concepts. The 2<sup>nd</sup> invited paper and the next session was focused on dynamic spectrum access, software defined and cognitive radio. These technologies offer solutions to overcome the problem of shortage of radio spectrum, by firstly assessing the usage of radio spectrum and a dynamic usage of the scarce resource 'frequency' by a software radio. The next 3 sessions covered special aspects of future radio systems, such as high data rate waveforms using innovative combined coding and modulation as well as networking concepts, which have been developed in the context of NATO working groups and US standardisation activities. Besides those activities final and intermediate results of several European initiatives have been presented: ESSOR, WOLF and ETARE. The 2 final sessions covered network, protocol and security aspects. Here to mention is the paper from the Canadian Communication Research Centre, which received the best paper award: it presented results of measurements of VHF radio signals, which in combination with tactical scenarios provide a baseline model for the designing multi-hop protocols. Papers on mitigation of security threats in tactical networks and on standardisation activities of mobile ad-hoc protocols concluded the presentations.

The Symposium offered an opportunity for a comprehensive exchange of information on the state-of-the-art in the mobile communications and examined the progress and future of communication technologies development and implementation to support Network Centric Operation. In combination with the MCC the Symposium concentrated experts who shared results from NATO and European initiatives. Such a setup might be considered worthwhile in the future.

# Communications et réseaux militaires

## (RTO-MP-IST-092)

### Synthèse

Le symposium s'est déroulé conjointement avec la Conférence sur l'information et la Communication Militaires (CCM), conférence reconnue qui réunit la plupart des experts européens dans le domaine des SIC militaires. Certaines sessions ont rassemblé les deux événements dans des domaines d'intérêt communs.

Le thème du symposium portait sur les systèmes de communication et les réseaux sans fil et ciblait les récents développements en la matière.

Le symposium était organisé en 3 sessions communes et 5 sessions réservées au symposium. La session plénière commune IST/MCC présentait un aperçu et deux articles d'intervenants invités. Le premier a apporté un éclairage sur les communications centrées sur l'humain, susceptibles de jouer un rôle significatif dans l'élaboration des réseaux sans fil selon les concepts du soldat du futur. Le deuxième article ainsi que la session suivante ont été centrés sur l'accès dynamique au spectre, la radio logicielle et la radio cognitive. Ces technologies apportent des solutions pour surmonter le problème d'absence de spectre radioélectrique, tout d'abord en évaluant l'utilisation du spectre radioélectrique et l'usage dynamique, par une radio logicielle, des « fréquences » limitées. Les 3 sessions suivantes ont couvert les aspects particuliers des futurs systèmes radio, tels que les impulsions à haut débit de données qui utilisent un système combiné de codage et de modulation innovant, ainsi que des concepts de mise en réseau, qui ont été développés dans le cadre des activités de groupes de travail de l'OTAN et de l'Institut de normalisation des Etats-Unis. Outre ces activités, les résultats intermédiaires et définitifs de plusieurs initiatives européennes ont été présentés : ESSOR, WOLF et ETARE. Les deux dernières sessions ont traité le réseau, le protocole et les aspects liés à la sécurité. Citons maintenant le document du Centre de recherche canadien pour la communication, qui a reçu le prix du meilleur article : il a présenté les résultats de mesures de signaux radio THF qui, associés aux scénarios tactiques, fournissent un modèle de base pour la conception des protocoles multi-sauts. La séquence des exposés a été clôturée par des articles portant sur l'atténuation des menaces pour la sécurité des réseaux tactiques et sur les activités de normalisation des protocoles mobiles ad-hoc.

Le symposium a offert un cadre d'échange d'informations sur les systèmes de communication mobiles de pointe et a examiné les progrès et l'avenir du développement et de l'application des technologies de communication en vue de soutenir l'opération de capacité en réseau de l'OTAN. Parallèlement au CCM, le symposium a rassemblé des experts qui ont pu partager les résultats des initiatives européennes et de l'OTAN. Un tel rassemblement peut s'avérer très utile à l'avenir.

## Technical Evaluation Report

### INTRODUCTION

This report addresses the IST-092 Military Communications and Networks symposium held in association with the MCIS week. The events were closely coupled with an overlap of disciplines and aims. It was evident from discussion with the participants that holding the events at one location was mutually beneficial. Five specific topics were associated with the IST element:

- Cognitive and software defined radios
- Waveform standardisation
- Waveform characteristics influenced by physical effects
- Waveform characteristics influenced by the network
- MANET aspects

The call for papers attracted an acceptable but disappointing response, when compared to learned society sponsored symposia. This can be rectified by the Panel members actively encouraging contributions from their national research institutes. The abstracts received allowed the programme committee to select from the contributions with twenty one papers establishing an acceptable programme. The duration of the presentations and the time allocated for questions was well judged. The quality of the papers was variable and the content provoked questions from the floor and useful discussion in the margins during breaks. The questions from the floor were considered and added to the understanding; when necessary prompted by prepared questions from the session chair which was good to see. The programme was supplemented with two invited papers and further by the Chief Technology Officer NC3A and the chair of the RTB giving presentations. The latter two providing the background and a wide sense perspective culminating in a list of priorities

### ISSUES

The issues of concern in the context of this symposium are:

- a) Security. The network layer is inherently vulnerable and we need to create robust systems.
- b) Maintain and establish interoperability. The level of interoperability is not as high as it might be but, increasing the degree may dilute security. This demands a systems approach.
- c) Spectral efficiency. We need to retain the necessary information flow despite higher demands on the resource.

### DISCUSSION

The authors addressed the issues to some degree and progress was offered to reduce the effects of the threats. It is recognised that some of the detail of the projects may have been omitted in the open forum, inclined readers are directed to the extensive references provided in the papers.

Dynamic Frequency Assignment was discussed with the aim to ensure necessary and sufficient communications. Spectral resources are finite and constrained by the physics of EM propagation exacerbated by the increase in bandwidth demanded by all users. The aim is to improve the efficiency using new technology and management techniques. Cognitive radio systems could achieve a measure of efficiency but assignment constraints must be relaxed together with an increase in the permitted

interference. Users will need to appreciate that dedicated channels will become history and allotments may be subject to negotiation during use. The concept of primary and secondary users was addressed and is a mechanism which should be pursued.

The waveform aspects offered evolutionary improvements with progress in a number of areas. The continued improvements in FPGAs and faster processing assists this development which was hampered by a reluctance by some companies to allow others to use waveforms covered by intellectual property rights. No IP constraints are now featuring in the procurement cycle which aids interoperability.

## **DETAIL OF THE PAPERS**

Burton as Chief Technology Officer NC3A raised some interesting research aspects and was supportive of the IST initiatives. He highlighted Cyber Defence and counter IEDs as specific areas where progress is required. The keynote speaker Walker also spoke in plenary session indicating that financial pressure will force change. He also had a list of priorities which includes disciplines associated with the IST. He further invited participants and particularly academics to become involved with the NATO Science and Technology enterprise initiative.

The technical committee had invited two papers, the first from Scanlon who discussed body centric communications. He addressed the transfer of information in the three modes: on-body, off-body and body-body. It is achieved through specifically designed antennas which are mounted on the clothing using the wearer as a ground plane. Polar diagrams were presented consistent with the ability to enable humans to be nodes in a network. The second invited paper was an overview of dynamic spectrum access by Maseng. He took a pragmatic approach expanding on the success of spectrum commons in commercial WiFi. A number of tools are available in the public domain to assign the spectrum equitably, these include Gaming Theoretic solutions and Auctions. Selection of the cost function is critical to the outcome since we know that a Nash Equilibrium is not unique in these systems.

Paper 1, as identified in the programme, was in broad agreement with Maseng and advocated the use of a spectrum broker which would adapt to the environment. Paper 2 addressed the particular issue of identifying spectrum for use by the emergency services for public safety. Of specific concern is the allotment following a crisis when the demands made by civilians is also high, as experience during recent disasters. The approach was described under project EULER which involves a number of industrial partners and adopts a flexible spectral management approach, regrettably no evidence was presented to gauge its performance in use.

Project ESSOR was presented giving the findings of a six nation collaboration to identify an appropriate waveform for SDR. An architecture has been designed which extends JTRS whilst retaining portability. A second project with similar aims was described created from an RTG initiative with different grouping. The simulation results were encouraging but both projects lacked feedback from the user groups.

Saarnissari considered a frequency domain approach to analysis and implementation and discussed synchronisation and notched filters in this context. He might benefit from extending his research to other transforms. Users should be alerted to the inherent latency of block processing applied in these schema.

In paper 6 Kolb presented his findings of using spectral assessment techniques to classify non cooperating transmitters; effectively inverting the problem. Haar and Cepstrum methods to identify specific characteristics were shown with their respective performance, a well balanced paper.

Two papers by Brown described NATO waveform standardisation for tactical VHF the so called Narrow Band Waveform. The design occupies the extant 25kHz channel and has four modes 20,31.5, 64 and 96

kbps. With the higher data rates caution should be exercised and consideration given to adjacent channels. His second, complementary, paper looked at the preamble design. Significant improvements over the legacy system was evident from the simulation results presented.

Atrat, paper 9, looked at porting legacy waveforms but restricted any modifications to small changes only. He identified some changes which approached the theoretical bound as shown with the simulation results. It was readily acknowledged, however, that with major changes radical improvements are possible but then ceases to reflect the legacy waveform.

A representative from Harris presented some development ideas which had been undertaken in conjunction with Rockwell Collins, an example of industrial collaboration to the benefit of the users. The developments offered 1.5 to 2.0 dBs of improvement through waveform changes, further improvements are possible if spatial diversity is incorporated. The paper provides detail and shows the results of simulation and supplemented with over the air measurements.

Fisher offered a system approach to analysing the necessary waveforms, no results or recommendations were offered. The method conforms to good engineering practice. A presentation on the WOLF project followed looking at robust links in an urban environment. The aims of the project are extensive with some nodes indoors and indeed underground. The frequency range proposed are 225-400 MHzs and 1.3-1.7 GHz which may tax the design to cover underground functionality. The project is at an early phase and no results were available.

The use of the NATO AEW airframe with an IP port was presented by Bird in paper 13. A system has evolved utilising HF, UHF and IRIDIUM as the bearers. Proven capability was presented by showing the outcome of a demonstration with several laptops on the aircraft with a chat capability. A second capability was the ability to control a UAV via a ground control station. This effectively extends the AEW capability to support a joint C2ISR Mission.

A second EDA sponsored project ETAR was discussed which looked at wideband waveform designs. A comprehensive design was presented, ETAR will enable interoperability through the software with a wide range of data rates and modulation schema. A security plane incorporating netsec, comsec and transec is present but questions relating to key management from the floor were not answered.

We now move to the declared critical topic of Network Design. A well prepared paper by Li provided the issues associated with the network layer. She gave some history before contrasting the demands of the military users with those of a generalised MANET. She then described her network model, based on link probabilities which could then be applied to observe hub behaviour. This paper was given the best paper award.

Libaek, paper 16, investigates the link layer design and addresses the system trades of:

- Transmission rate vs data rate
- Voice reliability vs data capacity
- Voice delay vs communication probability

Again simulation results were presented which showed that the design is robust but synchronisation in the absence of GNSS could be a problem.

Ginzler offered an approach for point to point routing with distributed architecture based on KADEMIA. Some results were shown but it is significant that the system has the property to force a termination. The following paper 18 was based on BGP (Boarder Gateway Protocols) which is declared mandatory for NATO network and information infrastructure services. BGP routes information between autonomous

clusters, each with its own router using a distributed management layer for exchange of routing policy. Search times are presented in the paper for a representative environment. Plesse addressed a similar problem in MANETs using IPv6 and presented results for a physically deployed network at DGA France.

The penultimate paper 20 analysed the vulnerability of networks and made comment on attack modes. It recognised that assistance from other layers would be an advantage and it is strongly recommended that security features are introduced at an early stage of the design. The final paper provides detail of OLSRv2 (Optimised Link State Routing) and was presented by Dearlove one of the authors of the standard. The enhancements over version one are the use of weighting function rather than the hop count and the capability of address compression.

## CONCLUSIONS

The overall impression of the symposium was good and the chairman and his technical committee should be congratulated on the quality achieved from the restricted number of abstracts. The papers described progress across a broad front which included some of the known issues in this area. Some useful research was exposed together with identifying areas where more work is required. Not all disciplines within the call for papers were addressed, of significance was the limited discussion of EW and IW aspects and the impact of reduced diversity when all systems conform to a standard.

A number of collaborative projects in both NATO and EDA appear to be bearing fruit. Further collaboration will only improve the situation particularly increasing participation from academia.

The event was worthwhile and timely and I would encourage future symposia with appropriate subjects be coordinated with the MCIS.

Glyn Wyman

TER IST-092